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Patents Resulting from NSF's Engineering Program*

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Summary

This report presents the results of a study of engineering research project grants funded by the National Science Foundation (NSF) between 1968 and 1977. The purpose was to determine the extent to which the grants led to patented technology and to estimate the economic value of those patents.

From the names of the principal investigators supported by NSF Engineering grants, who are also named as inventors on engineering patents registered with the U.S. Patent and Trademark Office, an examination was made by technology experts from SRI International, Inc. to determine the relevance of each grant to its associated patent. An independent assessment was also made to evaluate the commercial potential of each patent and to estimate its economic value.

The study found that from some 4077 NSF Engineering project grants awarded between 1968 and 1977, about 2.6 grantees in 100 produced patents linked to his or her grant. Some 248 patents were examined in this study. Although few patents produced any economic value, seven of these patents were licensed, with royalties ranging from $10 000 to $250 000 annually.

The total long-term royalties expected from the linked patents investigated is estimated as high as $52.5 million. The aggregate value to the U.S. economy from the sales of products derived from those patents could range between ten and twenty times that amount, depending upon the industry.

One observation from the study is that a strong patent licensing program is becoming valuable to universities, not just for producing royalty income, but for the additional sponsored research funds it attracts from industrial firms.

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†For example, The Patent and Trademark Act of 1980 (P.L. 96-517) gives general authorization to universities and colleges to promote inventions resulting from government funded research.

Introduction

Whether valuable patented inventions have resulted from academic research supported by National Science Foundation (NSF) grants has been debated among members of the National Science Board and by committees of Congress for some time. The recent agenda of the House Science and Technology Committee's Task Force on Science Policy included a review of government research support and patent policy as one of the issues to be studied.[1]

An academic scientist typically is interested in teaching, doing research, and in disseminating new scientific knowledge through publication and related activities. The discovery of commercial applications for an idea or invention has been of secondary importance. However, recent changes in U.S. patent policy have awakened interest among academic institutions to transfer their research results to the marketplace.

Although the Federal agencies have routinely recorded their contractor and grantee invention disclosures since the 1960s, few systematic studies have been undertaken to assess the significance of such patent activity or its value to the national economy. Moreover recent legislative developments† have focused attention on the need to identify and evaluate patented inventions as discrete and measurable outputs of Federally-supported research.

This paper summarizes a study of NSF Engineering patents performed during 1984 by SRI International, Inc., Menlo Park, CA, under NSF Contract EVL-83 19583. The work builds upon an earlier patent study of the NSF Chemistry Program performed by Research Corporation, New York, in 1982.[2] Both studies attempt to establish reliable baseline data for making future comparisons of university patent activity resulting from NSF grant support. The procedures used can be applied, with comparable effort, to evaluating patents associated with similar research grant programs elsewhere.

Purposes and Objectives

The purposes of this study are to determine the extent to which NSF Engineering Program grants produced

patented technology and to estimate the economic value of those patents. In addition, the study develops a systematic method for evaluating patents associated with university research grants and provides some quantitative statements useful for describing the university technology transfer process.

The objectives were to:

(1) Determine whether links exist between certain U.S. patents and NSF engineering grants.
(2) Determine whether the patents identified were ever licensed or judged commercializable.
(3) Estimate the aggregate economic value of those patented inventions found to have resulted from NSF Engineering Program support.
(4) Establish a reasonable basis for evaluating patents resulting from Federally-supported university research.

The approach taken was to examine a 10-year set of 4077 NSF engineering research grants in order to determine the extent to which those grants led to patented technology and to commercial use.

Scope of Study

The study involved some 722 patents issued between 1975 and 1982 to the 4077 principal investigators supported by NSF Engineering Program grants between 1968 and 1977. Because of grant document retrieval problems, which proved to be random,* only 149 grants associated with 248 patents were actually examined. This sample is considered to be representative of the total set of 4077 grantees.

Procedure

The first part of the study sought to determine the number of research grants supported by NSF's Engineering Program which also produced U.S. patents. The second part, performed by members of the Patent Review Board of SRI International (SRI), estimated the commercial potential and economic value of the patents found. They followed the patent evaluation process typically used in industry, which is summarized below. The results of an earlier patent study of NSF chemistry grantees[3] was used to provide a basis for comparison.

*Although attempts were made to retrieve these retired grant documents from the U.S. Archives, many of the original grant folders were not found due to misplaced, lost, or destroyed records. A statistical test (chi-square, equality of proportions along five attributes) confirmed that the missing data was random: thus the available sample of 149 is considered representative of the original population of 4077 grantees.

Caveat on Baseline Estimates

This study attempts to plough new ground in an uncertain and difficult area: the relationship between university research, patented inventions, and economic impact. The database used was constructed from the best information available at NSF and U.S. Patent and Trademark Office computerized files, which may have been incomplete. The results were derived from very conservative estimates, because of the nature of the PI/Inventor name-matching process used and the restricted availability of the licensing data. The time periods selected for analysis were chosen to best approximate the mainstream of grant-patent activity within the constraints of the data. Nevertheless, the evaluation method used is straightforward and provide a reasonable basis for arriving at the results found.

Sources of Data: Patents Related to NSF Engineering Grantees

The primary data sources used were the 'NSF Engineering Program History Tape', an unduplicated alphabetical listing of some 4077 principal investigators (PIs) supported by NSF's Engineering and applied research divisions between 1968 and 1977, and the U.S. Patent and Trademark Office's (PTO) computerized list of patents issued between 1975 and 1982. (Only U.S. patents issued after 1 January 1974 were accessable by computer from the PTO files.)

Typically it takes about 2 years after a grant is awarded to do the research, from 2 to 4 years to prepare and file a patent application based on that research, and an additional 2–7 years for prosecution in the PTO before a patent is issued. Based on these time requirements, it was assumed that grants awarded between 1968 and 1977 most likely supported the research which 7 to 10 years later produced patents issued between 1975 and 1982. This constituted the search grid for the study.

Using the names of the 4077 NSF Engineering Program grantees between 1968 and 1977, we made computerized matches were made with the names of inventors listed in the PTO's database files of engineering patents (mechanical, electrical, chemical, and structural) issued during the period January 1975 to December 1982. Similar name-matches had previously been made for the list of 3766 NSF Chemistry Program PIs receiving grants for basic chemistry research between the years 1964 and 1974.

The use of comparative data from the earlier NSF chemistry patent study was considered useful since both sets of grantees are based primarily on their scientific merits. The applied nature of engineering research, however, may have included the additional criterion of practical utility, which was expected to account for significant differences in the results.

by NSF grantees, who were not strictly Engineering program PIs during that time period.

A conservative estimate of the economic value of those patents resulting from NSF Engineering program support is on the order of $52 million. This estimate was based on SRI's experience in evaluating patents and in licensing high-technology inventions, including many which have resulted from basic university research.

The results of this analysis are:

- Seven of the 51 patents resulting from NSF-supported engineering research have been licensed or assigned to an industrial company and have contributed directly to industrial technology; eleven of the remainder are considered potentially licensable.

- The aggregate economic value of the eighteen NSF engineering patents found licensed or licensable is estimated at between ten and twenty times royalty income over the life of the patented product or process. (The total sales to date of the licensed patents cannot be determined with accuracy since adequate proprietary information was not available).

Analysis of Findings

The reasons for differences between the grant-patent data for the NSF Engineering Program and Chemistry Program are complex. A number of probable factors are suggested from related observations.

A comparison is shown (Table 2) between the Engineering and Chemistry program outputs. Basic research is more likely to result in dead ends or non-patentable results than is applied research or engineering.

The research proposals submitted to the NSF Engineering Program are inherently more applied in nature than those sent to the Chemistry Program. The review process employed by the two NSF programs differed; Chemistry evaluated their proposals by mail, whereas Engineering divisions used both external mail reviewers and *ad hoc* panels of experts who met to rate project proposals. While reviewers were instructed to rate proposals for 'scientific merit', there are indications in their written comments that engineering reviewers also gave weight to the practical utility of the anticipated research results.

For those 18 patents found to have commercial value, all were linked to PIs who admitted having been

Table 2. Comparison of results

	NSF Engineering Program	NSF Chemistry Program	Research Corporation chemistry grantees
Period covered	1968–77 (10 years)	1964–77 (14 years)	1964–74 (11 years)
Number of principal investigators (PIs)	4077	3766	915
Number of PIs named as inventors on any patent	395 (149)	73	57
Number of patents issued to these PIs	722 (248)	195	32
Number of patents linked to NSF sponsored research	148* (51)	95	16
Number of PI/Inventors whose NSF grants linked to patents	106† (40)	39	9
Patent ratio: (PI/I per 1000 grantees)	25.9 per 1000	10.4 per 1000	9.8 per 1000
Median time from grant award to filing patent application	3.8 years	5.2 years	6.4 years

*Factor of 0.205 used to project data (51/248 × 722 = 148 patents).
†Factor of 0.268 used to project data (40/149 × 395 = 106 PI/I)

consultants to industry or had prior industrial experience.

Why the Engineering Program patents were commercialized in less time than the other two groups is unclear. The data suggests that PIs who had prior industrial experience were better able to effect the commercial success of their patents.

Estimated Economic Value

As described earlier, the analysis of linked patents was limited by two conditions: (1) the difference between the period in which the grants were awarded (1968–1977) and the period in which the patents were issued (1975–1982), and (2) the lack of information about 474 patents known to be issued but for which grant information was not recovered. To reach quantitative conclusions about all linked patents issued to the grantees of interest, two statistical adjustments were made.

These two adjustments were made on the aggregate statistics of the patents examined. Considering the uncertainties of the evaluation process, this approach made it unnecessary as well as impractical to estimate the probability distribution of royalty income for each patent. Therefore, the midpoint of the range of potential royalties for each patent was used.

The sample of 248 patents showed that 92.7% of them had no commercial value. The midpoint value of the estimated royalties for the remainder was found to be approximately lognormally distributed.

A Monte Carlo simulation yielded a best estimate of the potential royalties of the 474 patents of $23.0 million. Combining this figure with the midpoint of the estimated royalties of the 248 patents examined gives an estimated total of $31.5 million in royalties for all patents known to have been issued.

To adjust for the difference between the grant award and patent issue periods, the distribution of the time lag between grant award and patent issue was determined. From this distribution, it was estimated that 60% of the patents that have been issued to the grantees were issued in the period 1975–1982. Therefore, the total royalties for all patents issued or to be issued to the group of PIs studied was estimated to be $52.5 million.

Additional Observations

One observation from this study is that a strong patent licensing program is becoming valuable to universities, not just for producing royalty income which typically is small, but for the additional sponsored research funds it attracts from industrial firms, both in the U.S. and from abroad.

Although there is insufficient evidence, to date, to know whether the recent (since 1980) shift in Federal and university patent policies toward commercializing university research results has affected U.S. competitiveness in high-technology markets, this study suggests a method for identifying and assessing the extent of university patent output attributable to Federal research grant programs.

Conclusions

Based upon the analysis of findings, the following conclusions are reached:

- Few commercialized patents resulted from NSF grants for engineering research or from the PIs who conducted the research. However, the findings for both the Engineering (3.6%) and Chemistry (1.04%) grantees studied are comparable suggesting that this is due more to the nature or direction of the research than to poor performance by the investigators.
- The PI/Inventor ratio of 26.8 per 1000 grantees, for the NSF Engineering Program, appears significantly higher than the comparable ratios (10.4 per 1000 and 9.8 per 1000, respectively) for the two more basic Chemistry research grant programs.
- The patents examined, which are linked to NSF Engineering research grants, had only a slight impact on technology to date, and can be expected to have a modest economic value in the long run.
- The PI's recognition and awareness of patents is greater today than it was 10–15 years ago.
- The median time (3.8 years) between grant award date and patent filing date is appreciably less than that found for the more basic chemistry grants.
- A strong university patent licensing program is becoming more valuable, not only for producing royalty income, but for the additional sponsored research funds it attracts from industrial firms.

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Selection Criteria

The first step in carrying out this study was to determine the extent to which the research supported by NSF's Engineering Program between 1968 and 1977 produced United States patents. The names of the PIs were matched by computer against the names of inventors listed on all patents issued by the PTO. For each match, a grantee institution was determined by reference to the inventor's name, address, and assignment of the patent. This information was later used to verify the name-identity of particular PIs and inventors.

To organize the substantive examination of the study, the full text of each patent identified was obtained from the PTO search and assigned to one of three categories using the selection criteria given in Table 1.

Table 1. Relevance of patents to grants

Category	Assignment criteria
Directly related	PI and patent inventor names are identical; NSF support acknowledged in patent.
Probably related	PI and patent inventor names are identical; Titles and/or subject matter of both grants and patents are related; Patent application date is concurrent with or follows grant award date.
Possibly related	PI and patent inventor names are identical; Titles and/or subject matter of both grants and patents are similar; Patent application date follows grant proposal date; University and geographic proximity.

Procedure for Determining Linkage of Patents to Grants

Each of the selected patents in which a named inventor and PI are identical was examined by a subject expert for possible 'relevance' of the subject matter of the patent to the research performed under the grant. About one in five of the patents (29 out of 149) contained acknowledgements to specific NSF grant support; for these no further examination for 'linkage' was considered necessary.

For the remaining grantees, the examination comprised a review of the original grant proposal, each interim and final technical report, and any publications resulting from the research. The technical details in these documents were compared with the specifications and claims in the associated patent. Finally, a 'patent relevance' judgment was arrived at by the subject expert and recorded on a special worksheet.

Findings:

The results of this part of the study are:

- 395 of 4077 (9.7%) NSF Engineering Program PIs were named as inventors on U.S. patents between 1975 and 1982.
- 722 patents were issued to the 395 NSF grantees; 248 of these 722 patents were issued to 149 PIs involving technology associated with the research supported by NSF.
- 51 (21%) of the 248 patents examined were found to be linked to NSF sponsored research.
- 40 of the 149 Engineering PIs had patents linked to their NSF grant. 17 patents issued to the remaining 109 grantees, which included funding acknowledgements to other NSF programs, were judged as not related to the research supported by the NSF Engineering Program.
- Median time from grant award to patent filing date was 3.8 years.

Economic Value of Patents

An economic assessment of each 'linked' patent was developed from information requested from the inventor, from the university patent administrator, or from patent owners to whom assignment of the patent had been made. A questionnaire was used to obtain information on whether the patent had been licensed, date of first sale if marketed, and estimates of total volume of business over the life of the patented products or processes. Although it is too early for full commercialization of patents covering research conducted in the 1968–1977 time period, the information on the early use of the patent itself provides a basis for estimating its potential value.

A majority of the patents examined were not licensed. For each "linked" patent, the technology covered, type of claims, and problems visualized in licensing the claims were analyzed. Most of the patents found were considered of doubtful licensability, i.e., they have limited commercial application, present insurmountable difficulties to protect against infringement, or have no apparent economic advantage over existing processes.

The actual economic value, to date (sales of patented products or processes) of these NSF Engineering patents is relatively small. This is because the full economic potential can take from 15 to 25 years longer to be realized. Also, the selection method used in this study rejected seventeen patents which were invented

In view of the contents described it is clear that the aim of the video is to be an introduction to the expanding use of computers in the daily work at the EPO. The target audience is in the first place new staff at the EPO as part of their introductory training. In the meantime, however, the video has proved to be a success when shown to visitors. The simple but accurate explanation of the mutual relations between the different databases was the feature most appreciated.

On the other hand, it is obvious that it was a low budget production, with no budget at all for special effects. But the camera, the recorder, the player (both U-matic), two monitors, a small mixing table and a lot of black coffee were excellent.

Only one concession was made. It proved to be difficult to take pictures directly from a terminal screen, especially when parts of that screen were to be enlarged for higher readability. Therefore print-outs were made from each screen output and then videoed.

Finally, the credits. The 15 minute video was made on U-matic cassette for the PAL system by two senior examiners, Mr. G. Mees and the author of this article.